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Samuels et al.

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(54) **HEAT TRANSFER CAMERA RING**

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G03B 17/55 (2006.01)

(52) **U.S. Cl.**
CPC ***G03B 17/55*** (2013.01); ***H04N 5/2252*** (2013.01); ***H04N 5/2254*** (2013.01); *H04N 5/2251* (2013.01)

(58) **Field of Classification Search**
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USPC 348/81, 208.99, 335, 222.1, 372–376, 348/231.7, 82, 83; 396/97, 571, 522, 572
See application file for complete search history.

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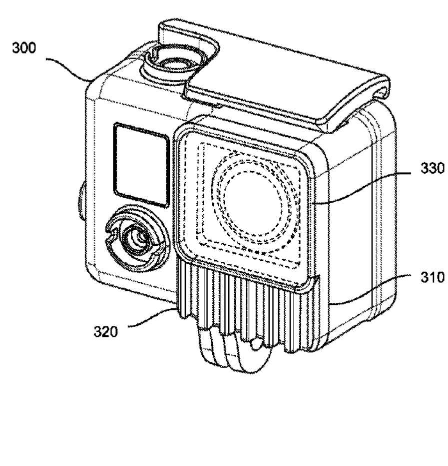
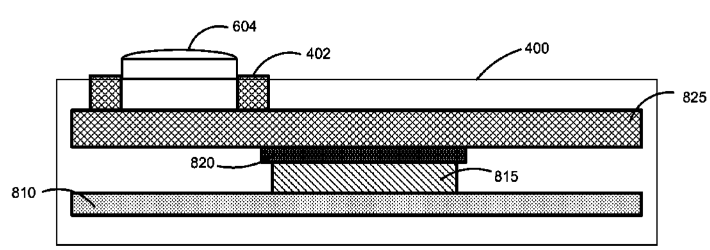
(57) **ABSTRACT**

A camera system includes a camera and a camera housing structured to at least partially enclose the camera. The camera comprises an internal heat sink thermally coupled to electronics of the camera and a lens ring positioned around a lens of the camera. The camera housing comprises a thermal conductor. An interior portion of the thermal conductor makes contact with the lens ring when the camera is enclosed within the housing, and an exterior portion extends outside the housing. The thermal conductor is configured to transfer heat from the interior of the housing to the exterior to dissipate heat from the camera's electronics.

20 Claims, 10 Drawing Sheets





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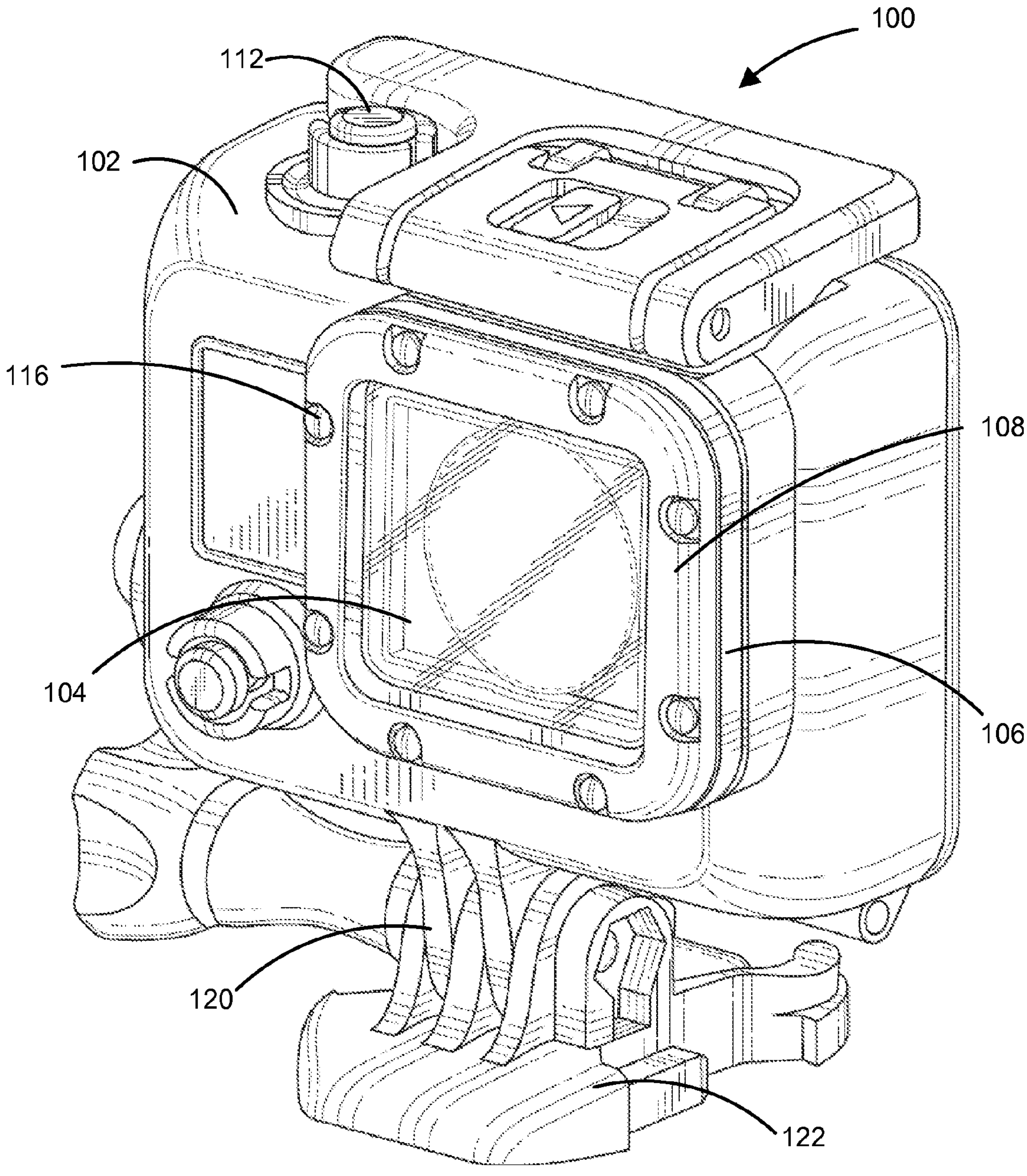

FIG. 1A

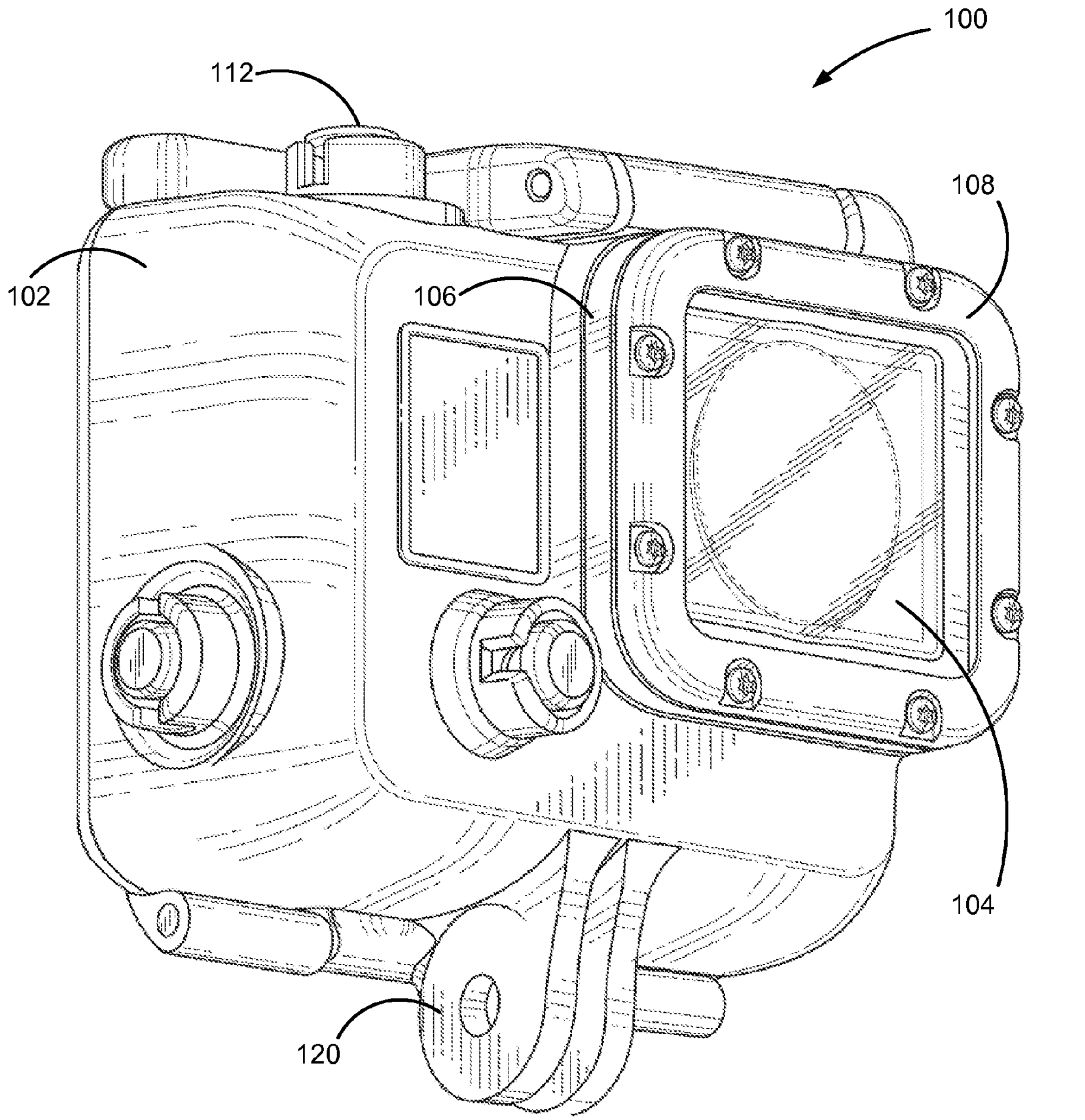

FIG. 1B

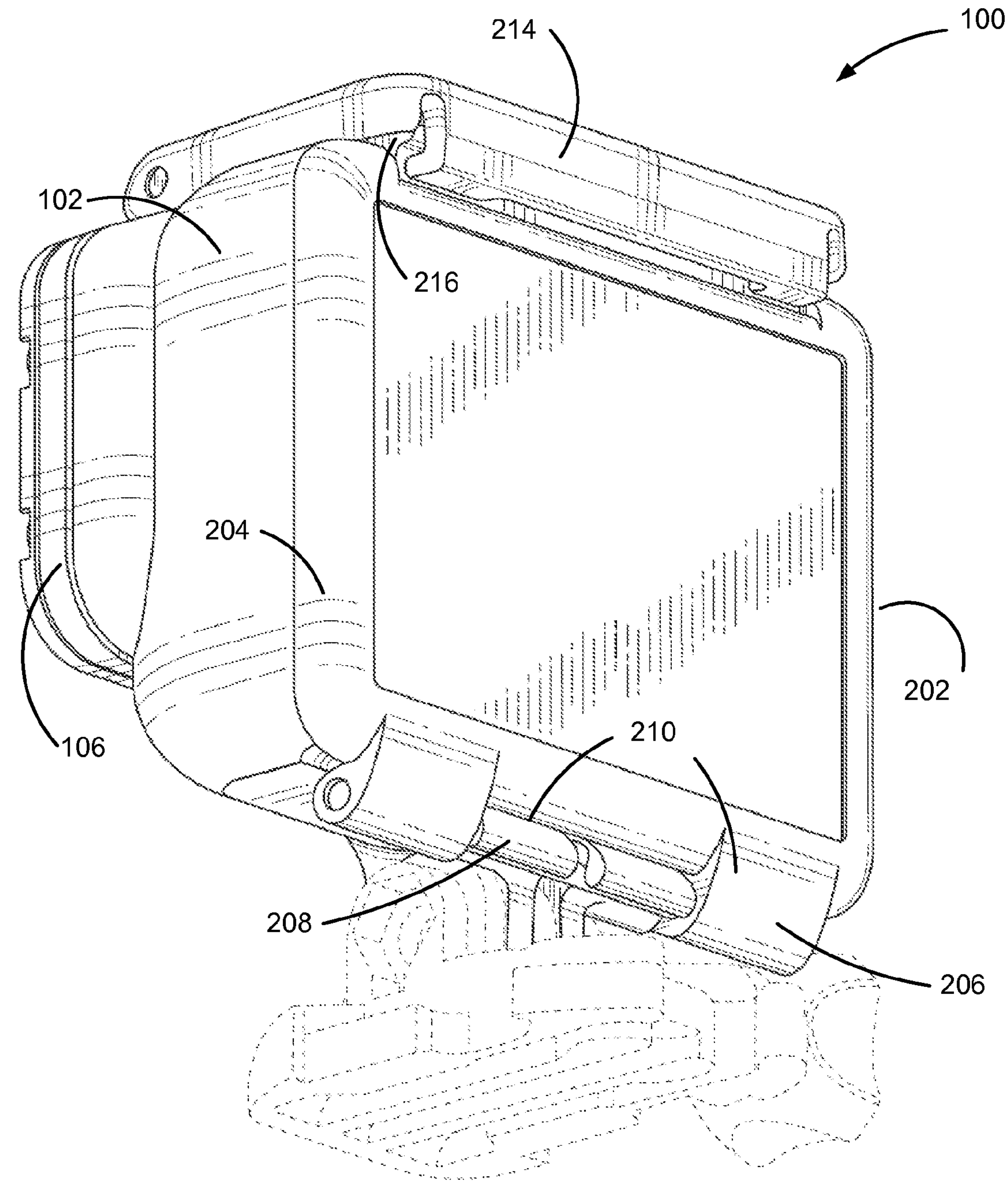

FIG. 2

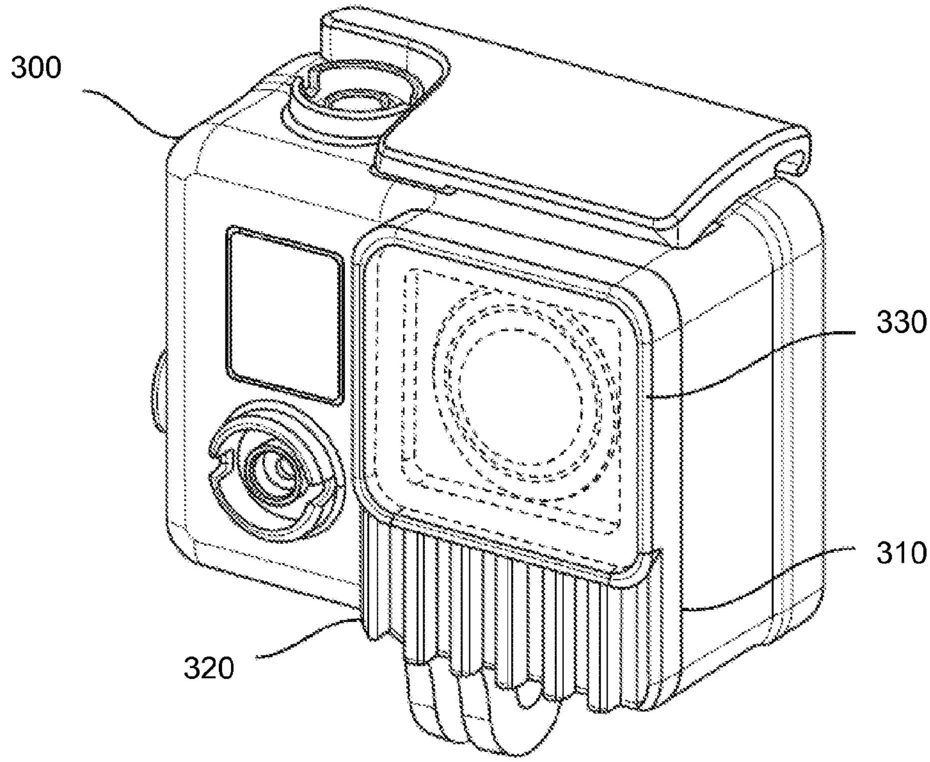

FIG. 3A

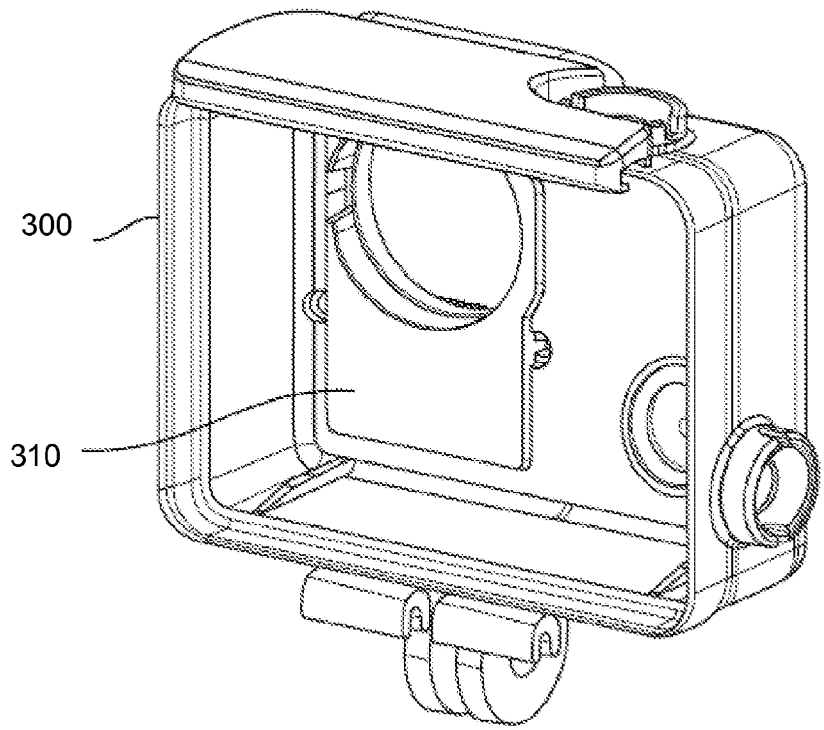

FIG. 3B

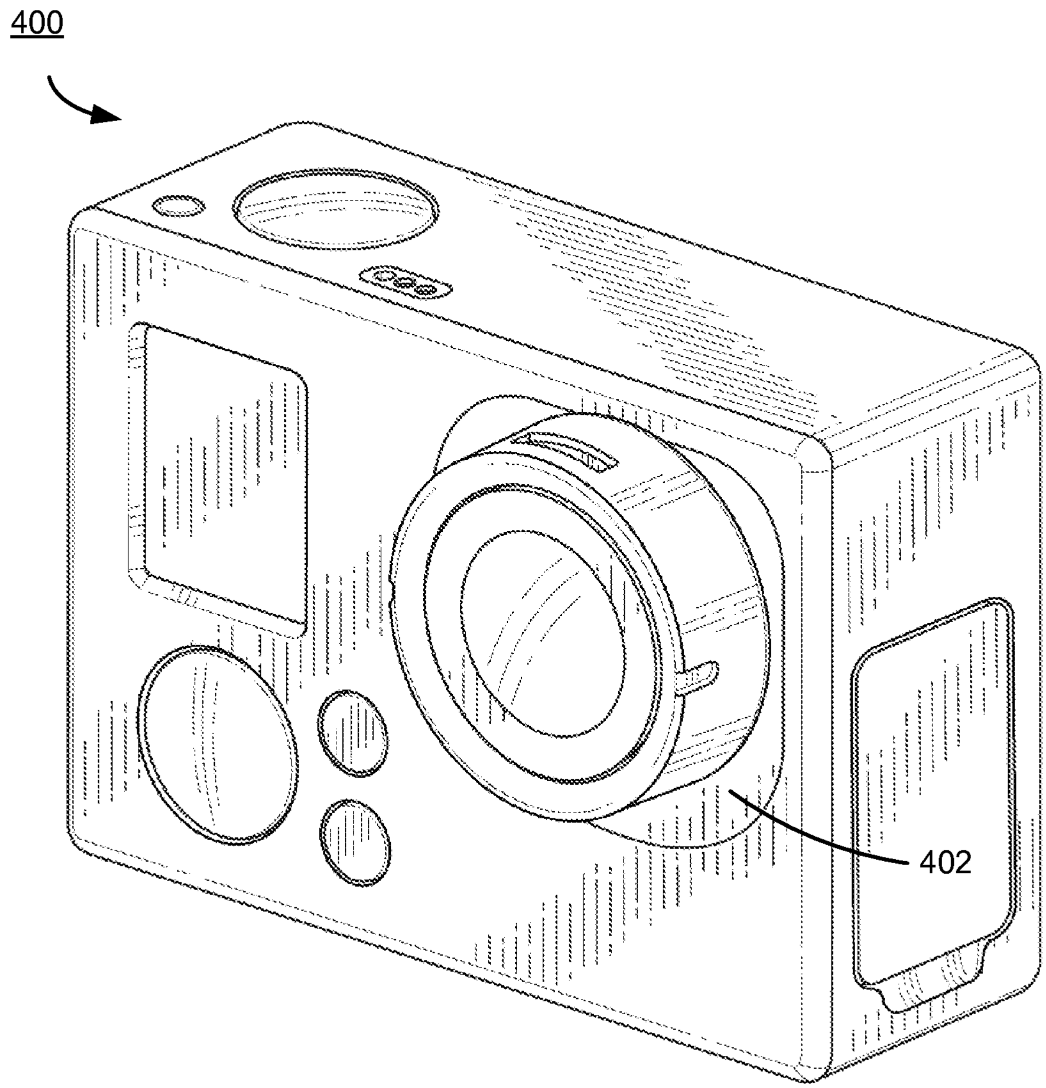

FIG. 4

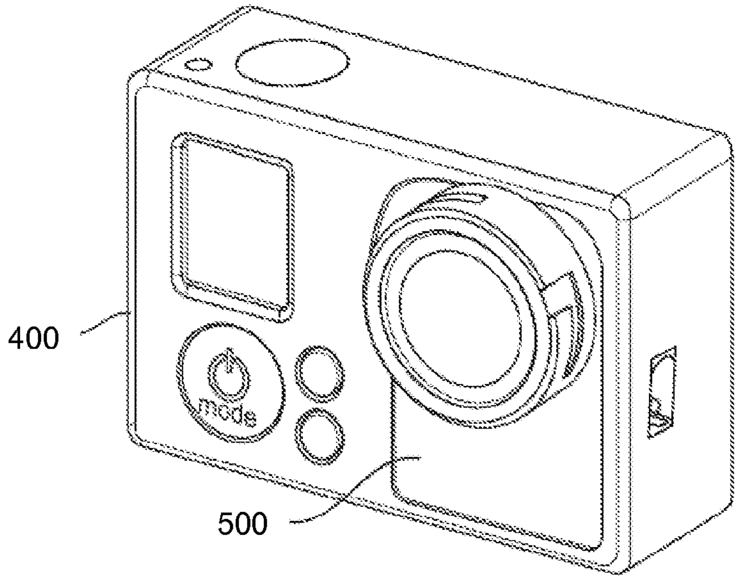

FIG. 5A

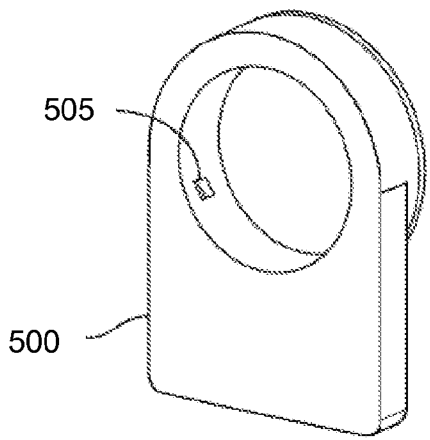

FIG. 5B

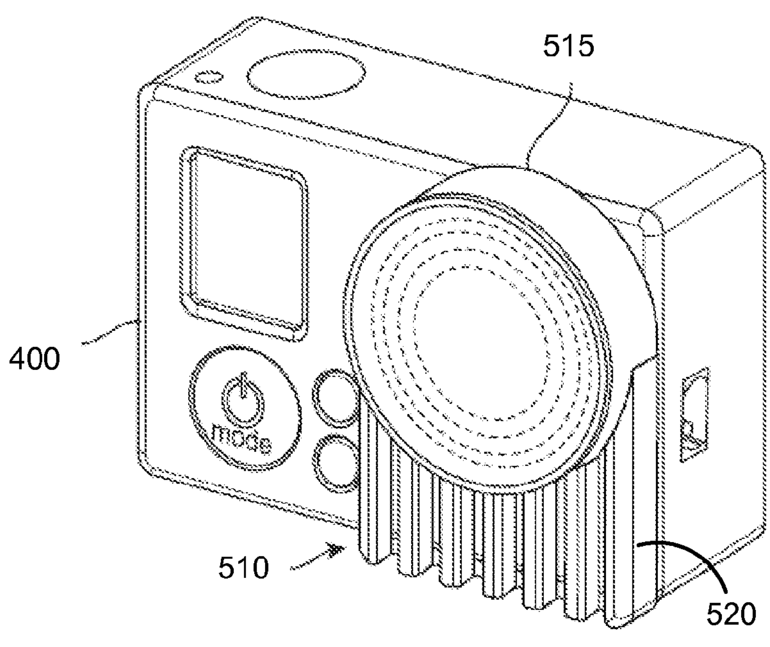

FIG. 5C

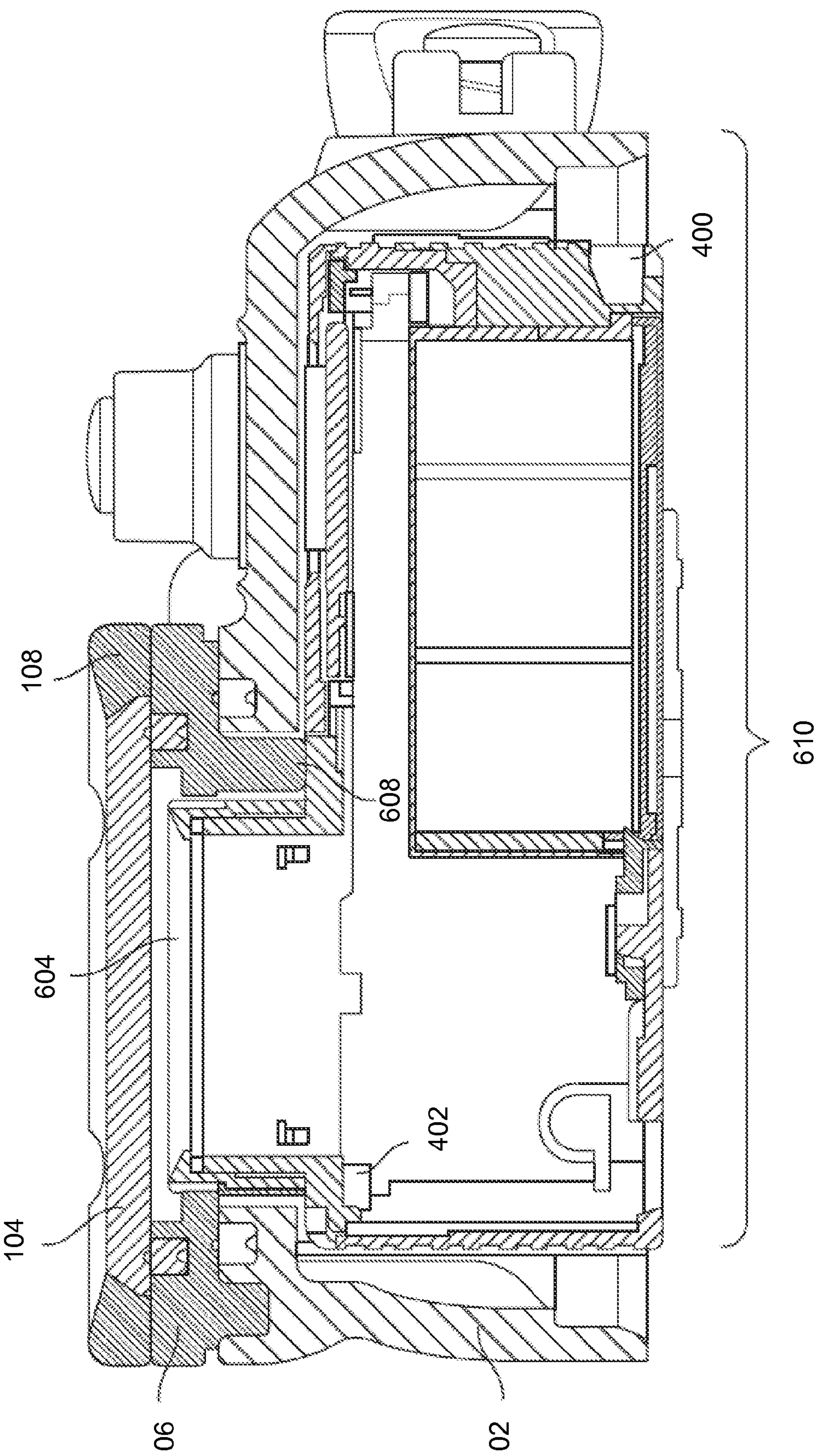

FIG. 6

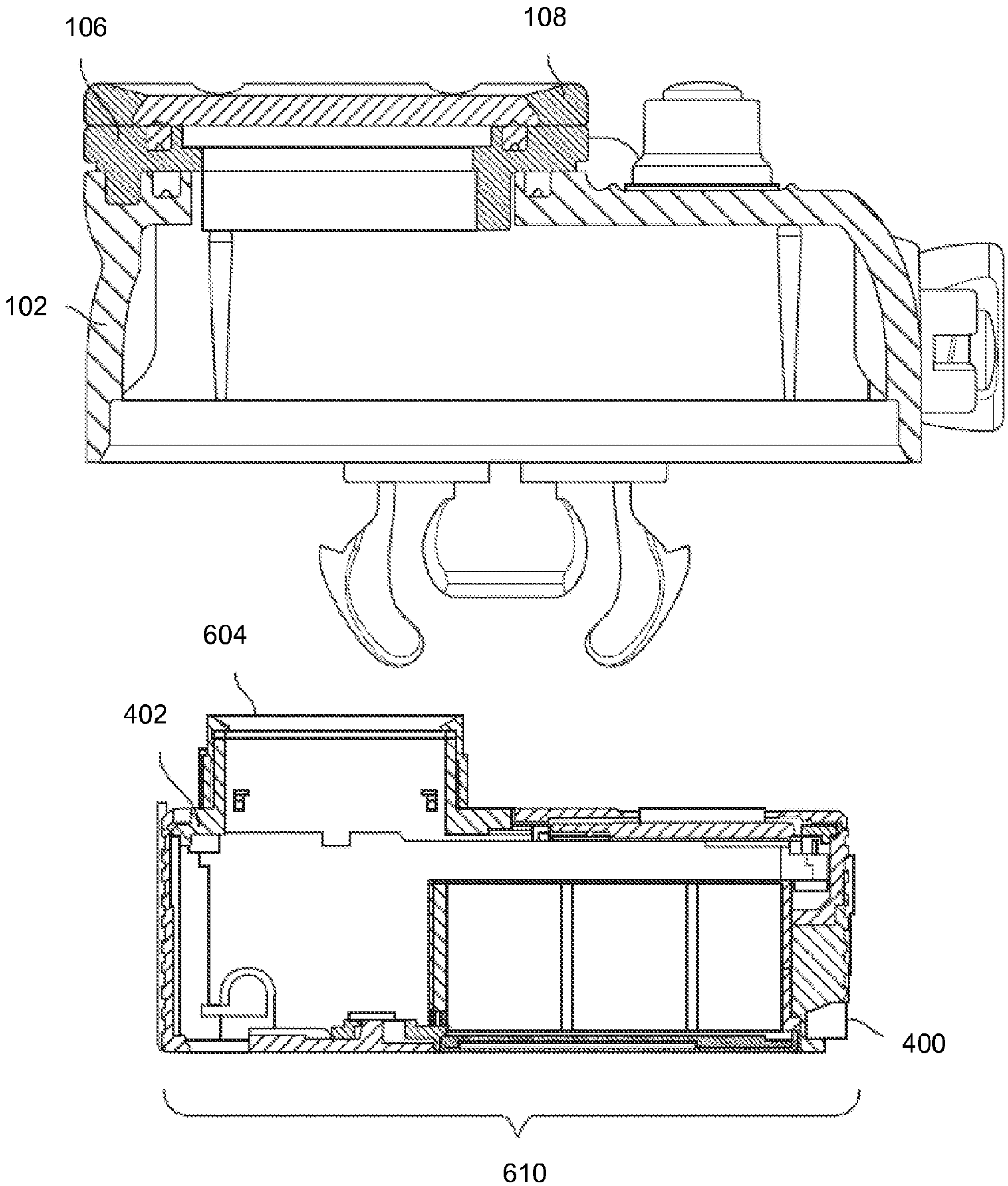

FIG. 7

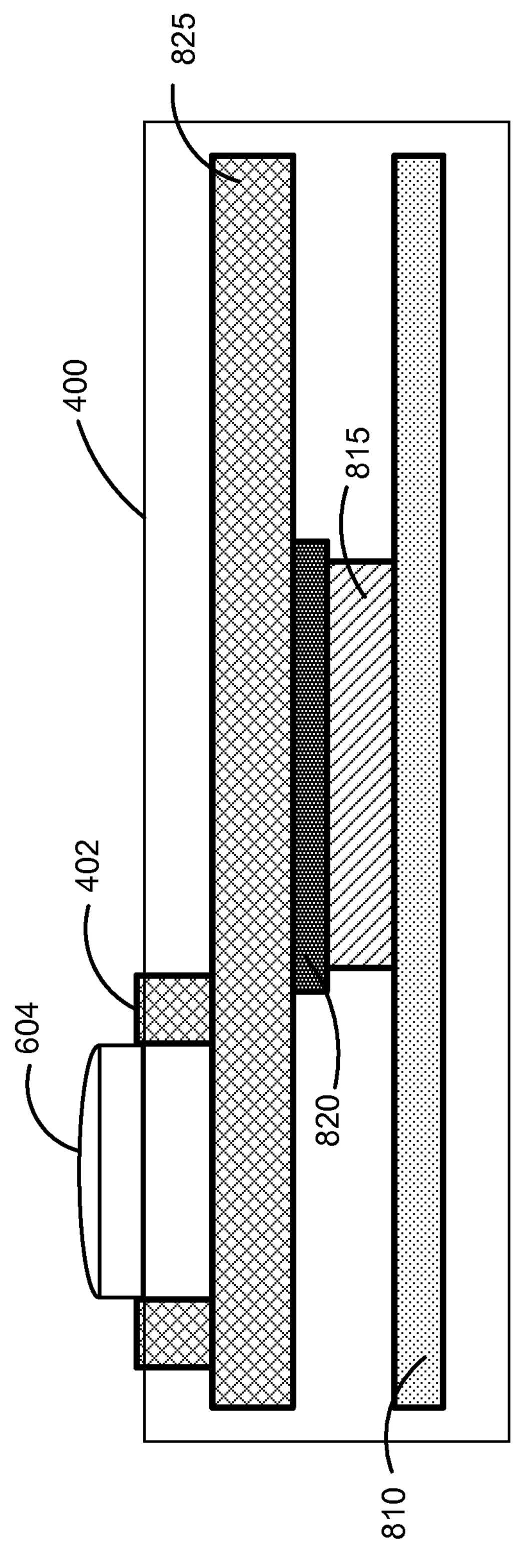

FIG. 8

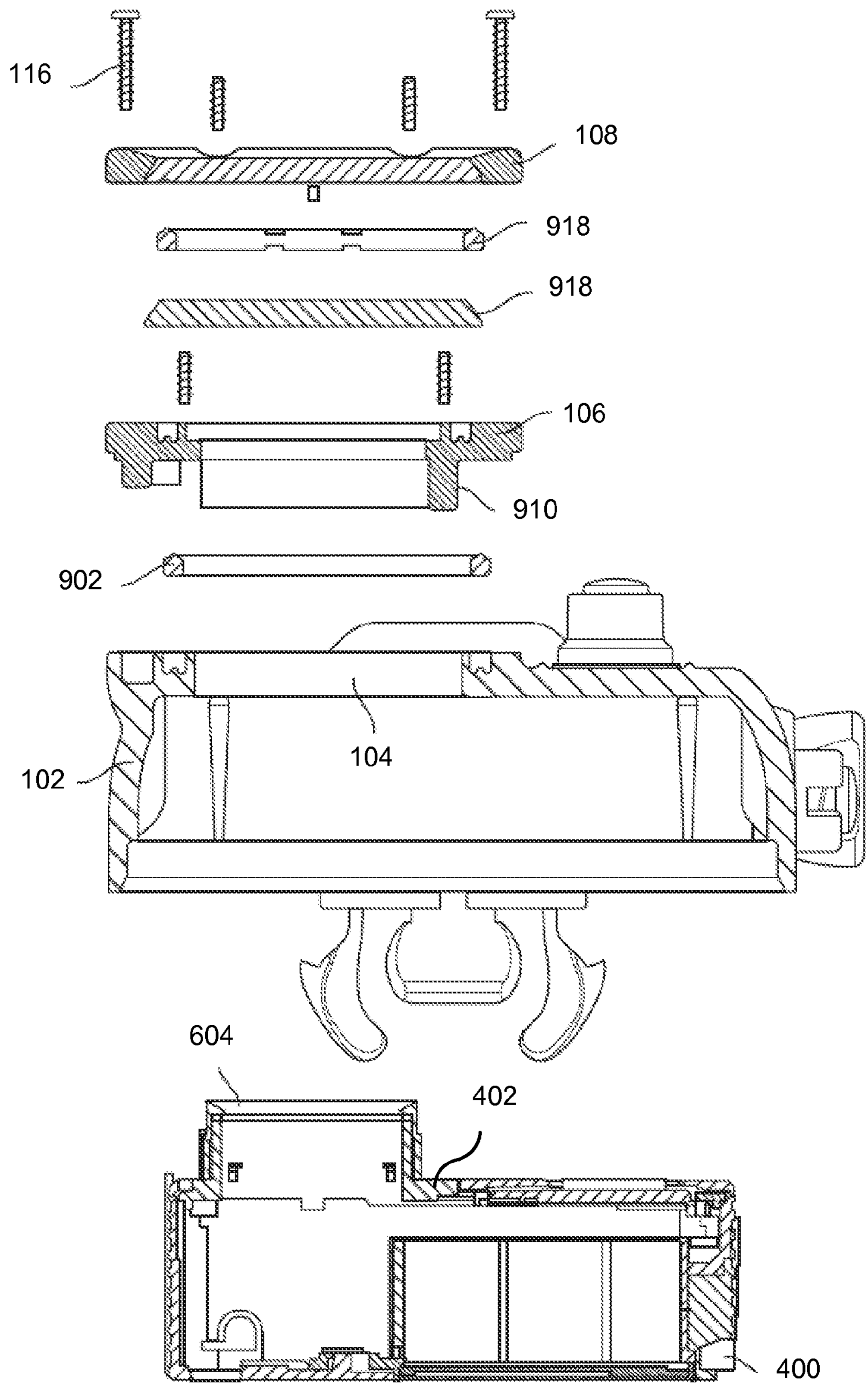

FIG. 9

HEAT TRANSFER CAMERA RING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/053,511, filed Oct. 14, 2013, now U.S. Pat. No. 9,025,080, which claims the benefit of U.S. Provisional Application No. 61/713,814, filed Oct. 15, 2012, and U.S. Provisional Application No. 61/860,168, filed Jul. 30, 2013, which are incorporated by reference in their entirety.

BACKGROUND

1. Technical Field

This disclosure relates to a camera system, and more specifically, to a heat sink for a camera system.

2. Description of the Related Art

Digital cameras are becoming faster and more powerful. As their capabilities improve, the processing power consumed to enable the faster speeds and greater resolution of modern digital cameras has increased significantly. When a digital camera is used over a long period of time, such as while capturing a video, the temperature of the electronics increases as a portion of the electrical energy is converted to thermal energy by resistive heating. In order to prevent damage to the electronics caused by high temperatures, it is beneficial to dissipate heat from the electronics. However, existing camera systems do not provide an efficient mechanism for heat dissipation. Furthermore, if the camera is placed inside of a closed protective case or waterproof housing, the housing may insulate the camera and restrict heat dissipation, thus increasing the likelihood of overheating.

BRIEF DESCRIPTIONS OF THE DRAWINGS

The disclosed embodiments have other advantages and features which will be more readily apparent from the following detailed description of the invention and the appended claims, when taken in conjunction with the accompanying drawings, in which:

FIG. **1**A illustrates a perspective view of a camera system, according to one embodiment.

FIG. **1**B illustrates an alternative perspective view of a camera system, according to one embodiment.

FIG. **2** illustrates a perspective view of a rear of the camera system, according to one embodiment.

FIG. **3**A illustrates an alternative perspective view of a camera housing, according to one embodiment.

FIG. **3**B illustrates a perspective view of the inside of a camera housing, according to one embodiment.

FIG. **4** illustrates a camera for use with the camera system, according to one embodiment.

FIG. **5**A illustrates a camera with a removable heat sink, according to one embodiment.

FIG. **5**B illustrates a removable heat sink, according to one embodiment.

FIG. **5**C illustrates a camera with a removable lens cover heat sink, according to one embodiment.

FIG. **6** is a top-down cutaway view of a camera within a camera housing, according to one embodiment.

FIG. **7** is a top-down cutaway view of a camera removed from a camera housing, according to one embodiment.

FIG. **8** is a schematic of a camera heat sink internal to a camera, according to one embodiment.

FIG. **9** is an exploded view of a camera system, according to one embodiment.

DETAILED DESCRIPTION

The Figures (FIGS.) and the following description relate to preferred embodiments by way of illustration only. It should be noted that from the following discussion, alternative embodiments of the structures and methods disclosed herein will be readily recognized as viable alternatives that may be employed without departing from the principles of what is claimed.

Reference will now be made in detail to several embodiments, examples of which are illustrated in the accompanying figures. It is noted that wherever practicable similar or like reference numbers may be used in the figures and may indicate similar or like functionality. The figures depict embodiments of the disclosed system (or method) for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles described herein.

Example Configuration Overview

A camera system includes a camera and a camera housing structured to at least partially enclose the camera. The camera comprises a camera body having a camera lens structured on a front surface of the camera body and electronics (e.g., imaging electronics, power electronics, etc.) internal to the camera body for capturing images via the camera lens and/or performing other functions. The camera further comprises an internal heat sink thermally coupled to the electronics for dissipating heat produced by the electronics. A lens ring thermally coupled to the internal heat sink is positioned around the lens of the camera on the front surface of the camera body. The lens ring transfers the heat produced by the electronics from the internal heat sink to an exterior of the camera body.

The camera housing includes an enclosure comprising a first material. A lens window of the camera housing is structured to substantially cover the camera lens of the camera when the camera is enclosed within the enclosure. The camera housing further includes a thermal conductor comprising a second material having a thermal conductivity equal to or higher than a thermal conductivity of the first material. The thermal conductor has an interior portion extending into an interior of the enclosure, the interior portion making contact with the lens ring of the camera when the camera is enclosed in the enclosure and providing a thermal conduction path away from the lens ring of the camera. The thermal conductor further includes an exterior portion having a surface outside the enclosure and forming at least a partial loop around the lens window of the camera housing. The thermal conductor is configured to transfer heat from the interior portion extending into the interior of the enclosure to the exterior portion having the surface outside the enclosure.

Example Camera System Configuration

A camera system includes a camera and a camera housing for enclosing the camera. FIGS. **1**A-B illustrate various views of the camera system in accordance with one embodiment. The camera system includes, among other components, a camera housing **100**. In one embodiment, a first housing portion **102** includes a front face with five sides (i.e. a top side, bottom side, left side, right side, and front side) structured to form a cavity that receives a camera (e.g. a still camera or video camera).

In one embodiment, the camera housing **100** has a small form factor (e.g., a height of approximately 4 to 6 centimeters, a width of approximately 5 to 7 centimeters, and a depth of approximately 2 to 4 centimeters), and is lightweight (e.g., approximately 50 to 150 grams). The camera housing **100** can be rigid (or substantially rigid) (e.g., plastic, metal, fiberglass, etc.) or pliable (or substantially pliable) (e.g., leather, vinyl, neoprene, etc.). In one embodiment, the camera housing **100** may be appropriately configured for use in various elements. For example, the camera housing **100** may be a waterproof enclosure that protects a camera from water when used, for example, while surfing or scuba diving.

Portions of the camera housing **100** may include exposed areas to allow a user to manipulate buttons on the camera that are associated with the camera functionality. Alternatively, such areas may be covered with a pliable material to allow the user to manipulate the buttons through the camera housing **100**. For example, in one embodiment the top face of the camera housing **100** includes an outer shutter button **112** structured so that a shutter button of the camera is substantially aligned with the outer shutter button when the camera is secured within the camera housing **100**. The shutter button of the camera is operationally coupled to the outer shutter button **112** so that pressing the outer shutter button **112** allows the user to operate the camera shutter button. In one embodiment, the front face of the camera housing **100** includes a lens window **104** structured so that a lens of the camera is substantially aligned with the lens windows **104** when the camera is secured within the camera housing **100**. The lens window **104** can be adapted for use with a conventional lens, a wide angle lens, a flat lens, or any other specialized camera lens. In this embodiment, the lens window **104** comprises a waterproof seal so as to maintain the waterproof aspect of the housing **100**.

In one embodiment, the camera housing **100** includes one or more securing structures **120** for securing the camera housing **100** to one of a variety of mounting devices. For example, FIG. **1**A illustrates the camera housing secured to a clip-style mount **122**. In other embodiments, the camera housing **100** can be secured to a different type of mounting structure.

The described housing **100** may also be adapted for a wider range of devices of varying shapes, sizes and dimensions besides cameras. For example, an expansion module may be attached to housing **100** to add expanded features to electronic devices such as cell phones, music players, PDAs, GPS units, or other portable electronic devices.

In one embodiment, a thermal conductor **106** is configured to at least partially surround the lens window **104**. The thermal conductor **106** comprises a material with a thermal conductivity equal to or higher than the thermal conductivity of the housing **100**, such as copper or aluminum. The thermal conductor **106** extends into an interior of the first housing portion **102** and makes contact with a thermally conductive lens ring positioned around the lens of the camera. When the thermal conductor **106** is in contact with the lens ring on the camera, conductive heat transfer may occur between the thermal conductor **106** and the lens ring of the camera, as will be illustrated in FIGS. **6-9** discussed below.

In one embodiment, the thermal conductor **106** is configured to have a substantially rectangular cross-section, as illustrated for example in FIG. **1**A, and may include rounded corners. Alternatively, the thermal conductor **106** may have a substantially square or substantially circular shape to conform to a shape of the lens window **104**. In another embodiment, the thermal conductor **106** may feature additional structures configured to increase the surface area of the thermal conductor **106**. For example, the thermal conductor **106** may comprise laterally-protruding fins, forming a spike or rib pattern at least partially surrounding the lens window **104**.

An insulating plate **108** may be positioned to at least partially cover a front surface of the thermal conductor **106**. The insulating plate **108** may comprise a thermally insulating material, such as plastic, and may be affixed to the thermal conductor **106** by one or more screws **116** or any other suitable fastening mechanism. In one embodiment, the insulating plate **108** may protect users of the camera from incidental contact with the thermal conductor **106**, which may become hot during use. In one embodiment, the insulating plate **108** may have a larger diameter than the thermal conductor **106** such that the thermal conductor **106** is partially recessed under the insulating plate **108**, further preventing incidental user contact with the conductor ring **106**. Thus, in this embodiment, most of the heat is permitted to escape around the perimeter of the thermal conductor **106** instead of through the front face, thereby reducing the likelihood of direct contact from the user.

FIG. **2** is a rear perspective view of camera housing **100**, illustrating a second housing portion **202**. The second housing portion **202** detachably couples with the first housing portion **102** opposite the front face of the first housing portion **102**. The first housing portion **102** and second housing portion **202** are collectively structured to enclose a camera within the cavity when the second housing portion **202** is secured to the first housing portion **102** in a closed position.

In one embodiment, the second housing portion **202** comprises a door **204** that allows the camera to be removed from the housing **100**. The door **204** pivots around a hinge **210** that allows the door **204** to be opened or shut. In one embodiment, a first fastening structure **214** located on the top face of the camera housing **100** detachably couples to a second fastening structure **216** on the door **204**. The fastening structures **214**, **216** secure the door **204** to the first portion **102** of the camera housing **100** in a closed position when coupled, as illustrated in FIG. **2**. In one embodiment, the fastening structure **214** comprises a hook-shaped lateral bar and the fastening structure **216** comprises an L-shaped bar. The fastening structure **214** can pivot upwards to allow the door **204** to close and can then be pressed down around the fastening structure **216** to hold the door **204** in the closed position. In different embodiments, fastening structures for securing the door **204** can include, for example, a button assembly, a buckle assembly, a clip assembly, a hook and loop assembly, a magnet assembly, a ball and catch assembly, and an adhesive assembly, or any other type of securing mechanism.

In one alternative embodiment, the hinge **210** is instead located on the top face of the housing **100** and the fastening structures **214**, **216** are instead located on the bottom face of the housing **100**. Alternatively, the hinge **210** and fastening structures **214**, **216** may be located on opposite side faces of the camera housing **100**.

In one embodiment, the housing **100** includes a watertight seal so that the housing **100** is waterproof when the door **204** is shut. For example, in one embodiment, the door **204** includes a sealing structure positioned on interior edges of the door **204**. The sealing structure provides a watertight seal between the first portion of the camera housing **102** and the door **204** when the first securing structure **214** on the top face of the camera housing **100** is coupled to the second securing structure **216** on the top edge of the door **204**.

In one embodiment, an outer hinge structure **206** on the bottom edge of the second housing portion **202** detachably couples to an inner hinge structure **208** on the bottom edge of the first housing portion **102** to form the hinge **210**. For example, in one embodiment, the outer hinge structure **206** comprises one or more hook-shaped protrusions structured to securely fasten to a rod-shaped member of the inner hinge structure **208**. Other mechanisms for coupling the second housing portion **202** to the housing **100** may also be used in various alternative embodiments. In other embodiments, the second housing portion **202** may be permanently attached to the first housing portion **102**.

FIG. **3**A illustrates a perspective view of an alternative embodiment of the camera housing. The camera housing **300** of FIG. **3**A shows the first housing portion with a thermally conductive portion **310** configured to allow for the transfer of heat from the camera to outside the housing. In the embodiment of FIG. **3**A, the thermally conductive portion **310** includes fins **320** and a lens window **330**. The lens window **330** can be configured to align with a camera lens when a camera is securely enclosed within the housing. The fins **320** protrude from the front face of the housing **300** and run from the bottom of the thermally conductive portion **310** to the lens ring **330**. The fins **320** create wind resistance that causes greater heat dissipation from the fins **320**. Thus, the fins **320** beneficially allow for more heat transferred from the camera to the lens ring **330** to be dissipated than is dissipated by a thermally conductive portion with a flat front face.

FIG. **3**B illustrates a perspective view of the inside of a first portion of a camera housing and the thermally conductive portion **310**, according to one embodiment. The thermally conductive portion **310** can be configured to align and thermally couple with a thermally conductive ring on the front face of a camera, allowing heat to be transferred from within the camera to the thermally conductive portion **310** of the housing.

FIG. **4** illustrates an example embodiment of a camera **400** for use with the camera system. The camera **400** is adapted to fit within the enclosure of the housing **100** or **300** discussed above. As illustrated, the camera **400** includes a lens ring **402** around a lens of the camera **400**. The lens rings **402** comprises a conductive material thermally coupled to internal electronics of the camera **400** and adapted to dissipate heat produced by the internal electronics. When placed within the housing **100**, the lens ring **402** makes physical contact with an interior portion of the thermal conductor **106** of the camera housing **100**, thereby providing a path for heat to dissipate externally to the housing **100**.

In one embodiment, as illustrated in FIGS. **1**A, **1**B, and **4**, the thermal conductor **106** is fixed to the housing **100** and the lens ring **402** is fixed to the camera **400**. In other embodiments, one or both of the thermal conductor **106** and the lens ring **402** are removable from the housing **100** and the camera **400**, respectively. Various embodiments of a removable lens ring and thermal conductor are illustrated in FIGS. **5**A-C and described in further detail below.

Referring to FIG. **5**A, illustrated is one embodiment of a camera **400** with a removable lens ring **500**. In the embodiment of FIG. **5**A, the lens ring **500** is coupled to the camera **400**. The lens ring **500** is made of a thermally conductive material. As described above, the lens ring **500** couples to internal heat-producing camera components, allowing heat generated within the camera **500** to be transferred via the lens ring **500** to the exterior of the camera **400**.

It should be noted that although the lens ring **500** in the embodiment of FIG. **5**A encircles the lens of the camera **400** and partially extends down the face of the camera **400**. In other embodiments, a thermally conductive surface thermally coupled to internal electronics of the camera **400** may not encircle the lens, and may instead couple to other portions of the front face of the camera **400** or any other camera faces, or the entire front camera face. It should also be noted that portions of the lens ring **500** can be covered by a thermally insulating material, protecting users of the camera **400** from incidental contact with the lens ring **500**.

In various embodiments, to couple to the camera **400**, the removable lens ring **500** is inserted within a reciprocal cavity within the front face of the camera **400**. In some embodiments, some portions of the lens ring **500**, when inserted within the reciprocal cavity, form a substantially smooth surface with the front face of the camera **400**, while other portions of the lens ring **500** protrude from the front surface of the camera **400** (for instance, the portions encircling and immediately adjacent to the lens).

In a first camera operating mode (such as a low power mode or a low resource-intensive mode), a relatively non-thermally conductive component (such as a plastic lens ring and front camera face) can be inserted within the reciprocal cavity. In the first operating mode, less heat dissipation may be required for operation, and use of the lens ring **500** may not be required. In a second camera operating mode (such as a high power mode or a high resource-intensive mode), the non-thermally conductive component can be removed from the reciprocal cavity, exposing the thermally conductive components within the camera **400**, and the lens ring **500** can be inserted into the reciprocal cavity. In the second operating mode, greater heat dissipation may be required for operation, and use of the lens ring **500** may be beneficial. Accordingly, use of the removable lens ring **500** can enable camera operation modes that generate high amounts of heat.

FIG. **5**B illustrates a removable lens ring **500**, according to one embodiment. In the embodiment of FIG. **5**B, the lens ring **500** couples to the camera **400** via a bayonet mount. The lens ring **500** includes at least one bayonet mount slot **505** configured to couple to one or more lens ring pins. The back of the lens ring **500** is substantially flat, allowing the lens ring **500** to maximize surface area contact with a flat thermally conductive component within the camera **400**. The removable lens ring **500** also includes a hole configured to encircle a camera lens. Such a configuration allows the camera **400** to capture light via the camera lens normally, without the removable heat sink **500** blocking the light. In some embodiments, the removable heat sink is shaped differently than in the embodiment of FIG. **5**B, and/or couples to the camera via other mechanisms.

In one embodiment, a removable lens cover can couple to the front of the camera **400** such that the lens cover is thermally coupled to the lens ring **402** or the removable lens ring **500**. The removable lens cover is configured to further increase heat dissipation from the heat-generating components of the camera **400**. For example, the removable lens cover can be attached to the camera **400** during high power or high resource-intensive operating modes for dissipating a greater amount of heat from the camera **400** than that dissipated by the lens ring **402** or **500** alone. FIG. **5**C illustrates a camera **400** with a removable lens cover **510**, according to one embodiment. The removable lens cover **510** is made of a thermally conductive material, and couples to the front of the camera **400**. In some embodiments, the lens cover **510** couples to the camera when the removable lens ring **500** is coupled to the camera. In other words, the removable lens ring **500** can be coupled to the camera **400** within a reciprocal cavity, and the removable lens cover **510** can couple to the camera **400** over the lens ring **500**. In other embodiments, the lens cover **510** thermally couples to the fixed lens ring **402** of the camera **400**. The lens cover **510** can be configured to make thermal contact with the lens ring **402** or **500**, such that heat generated within the camera **400** can be thermally transferred to the lens ring, from the lens ring to the lens cover **510**, and from the lens cover **510** to the exterior of the camera **400**. In some embodiments, the lens cover **510** can couple to the camera **400** when the camera **400** is not coupled to the removable lens ring **500**. In such embodiments, the lens cover **510** makes thermal contact with thermally conductive points exposed on the camera surface, allowing heat to transfer from within the camera **400** to the lens cover **510**.

The removable lens cover **510** of the embodiment of FIG. **5**C includes a lens ring **515** and a plurality of fins **520** protruding from the front face of the lens cover and running from the bottom of the lens cover **510** up to the lens ring **515**. As noted above, the fins **520** create wind resistance that can improve the dissipation of heat transferred to the removable lens cover **510**. In other embodiments, the lens cover **510** includes fewer or more fins that may be arranged in differing configurations than that illustrated in FIG. **5**C.

Heat Sink for Camera System

FIG. **6** is a top-down cutaway view of the camera system including the camera **400** and the first housing portion **102**. FIG. **7** illustrates a similar viewing perspective with the camera **400** removed from the first housing portion **102**. Camera **400** comprises a camera body **610** and a lens **604** located on a front surface of the body **610**. The camera **400** fits inside a cavity of the first housing portion **102** such that the lens **604** of the camera **400** is aligned with the lens window **104** of the housing **100**. When placed inside the camera housing **100**, the camera **400** is enclosed and protected by the camera housing **100**.

The camera **400** comprises electronics that capture digital images and/or video via the camera lens **604**. During operation of the camera, a portion of the electrical energy used by the electronics is converted to heat due to resistive components of the electronics. This heat can cause performance problems or damage to the electronics. Furthermore, if the housing **100** is waterproof, the housing **100** may insulate the camera **400** and prevent dissipation of the heat. It is therefore desirable to dissipate the heat away from the electronics by thermally coupling a heat sink to the heat-producing electronics of the camera.

Generally, the camera system heat sink increases an effective surface area from which heat is transferred away from the electronics. For example, in one embodiment, a heat sink for the camera system comprises a conductive structure (e.g., a metal) thermally coupled to the electronics within the camera. The internal heat sink structure may be coupled to a thermally conductive lens ring **402** or a removable lens ring **500** positioned around an external region of the camera lens **604**, thus providing a conduction path to the surface of the camera **400**. When enclosed in the housing **100**, the lens ring **402** of the camera **400** makes contact with an interior portion of a thermal conductor **106** on the housing **100** (e.g., at a contact point **608**). During operation of the camera, heat produced by the electronics is therefore conductively transferred to the thermal conductor **106** of the housing **100** via the lens ring **402** of the camera **400**. The heat may then be dissipated to the surrounding environment (e.g., air or water) by conduction and/or convection via an external portion of the thermal conductor **106** that extends to an exterior of the camera housing **100**. Thus, by structuring the camera housing **100** to provide a conduction path from the camera to an exterior of the housing, the camera **400** can achieve significantly improved temperature regulation.

Due to process variation during manufacturing of the camera **400** and the housing **100**, the relative fit between the camera **400** and housing **100** may vary somewhat between different instances of the camera **400** and the housing **100**. If the housing **100** and camera **400** are not precisely matched, an air gap of variable thickness may exist at interface **608**, and the lens ring **402** of the camera **400** may not firmly contact the thermal conductor **106** of the housing **100**. Any imprecision may prevent the camera from fitting snugly inside the housing **100** (e.g., the camera might rattle), which may result in unsteady video, blurry images, or physical damage to the camera. In addition, the low thermal conductivity of air may significantly decrease heat flux from the chip and therefore decrease the effectiveness of the heat sink. These potential disadvantages can be overcome in one embodiment by including a compressible structure between the camera **400** and door **204** of the camera housing **100**. For example, the compressible material may be adhered to an interior of the door **204** and may be configured as a ring or in one or more rectangular strips. When the camera **400** is enclosed in the housing **100**, the compressible material pushes the camera **400** to the front of the housing **100** to ensure contact between the lens ring **402** and the thermal conductor **106**. The compressible nature of the material allows it to compensate for variations in the size and structure of the camera housing **100** and camera **400** and ensure that sufficient contact is made between the lens ring **402** and the thermal conductor **106**.

FIG. **8** illustrates an embodiment of the internal components of a camera **400**. Electronics of the camera **400**, including, for example, a chip **815**, are mounted on a printed circuit board (PCB) **810** that is secured internally to the camera **400**. The chip **815** is thermally coupled to a conducting plate **825**. In one embodiment, the conducting plate **825** comprises a material having a high thermal conductivity. For example, the conducting plate **825** may comprise copper, aluminum, or composite materials such as E-material or alloys of aluminum or copper.

In one embodiment, thermal paste **820** may be used to improve the efficiency of heat transfer between the chip **815** and the conducting plate **825**. Thermal paste **820** may be any material having a high thermal conductivity that is capable of preventing air gaps between the chip **815** and the conducting plate **825**, such as a phase change metal alloy or silicone, metal, or ceramic thermal compounds. The thermal paste **820** may further ensure that the conducting plate **825** remains coupled to the chip **815** when the camera **400** is subjected to shock or vibration, for example when used during physical activity. Other materials suitable for ensuring thermal coupling between the conducting plate **825** and the chip **815** may be used in place of thermal paste **820**.

The conducting plate **825** is also thermally coupled to a thermally conductive surface on the front face of the camera **400**, such as the lens ring **402**. In one embodiment, the lens ring **402** is positioned at a base of the camera lens **604**. The lens ring **402** is illustrated as protruding slightly from the front face of the camera **400** in FIG. **8**. However, in other alternative embodiments, lens ring **402** may be substantially flush with the front face of the camera **400**, or may be recessed within the camera **400**. In another alternative embodiment, lens ring **402** may protrude further from the camera **400** (e.g., to be substantially the same length as the lens **604**). As illustrated in FIG. **8**, the thermal paste **820**, conducting plate **825**, and lens ring **402** form a conductive path from the chip **815** to the front face of the camera **400**.

FIG. **9** is an exploded view of the camera system, illustrating the various components of the camera heat sink in relation to the camera system. The camera **400** fits within the first camera housing portion **102** such that the lens **604** is aligned with the lens window **104**. The thermal conductor **106** couples to the first camera housing portion **102** by connector **902**. In one embodiment, connector **902** forms a watertight seal between the thermal conductor **106** and the first housing portion **102**. When attached to the housing, the interior portion **910** of the thermal conductor **106** extends through the lens window **104** into the interior region of front housing portion **102**. The interior portion **910** makes contact with the lens ring **402** when the camera **400** is enclosed in the housing **100**. The insulating plate **108** is affixed to the front surface of the thermal conductor **106** by screws **116**. In one embodiment, various standoffs **918** may be positioned in between the thermal conductor **106** and the insulating plate **108**. The insulating plate **108** generally has a lower conduction coefficient than the thermal conductor **106**, and can therefore act to prevent a user of the camera from incidental contact with the thermal conductor **106**.

When assembled, the camera system as illustrated in FIG. **9** comprises the heat sink thermally coupled to the electronics of the camera and configured to extend to the exterior of the camera. The thermal conductor **106** of the camera housing **100** is configured to transfer the heat from the exterior of the camera **400** to the exterior of the camera housing **100**. As a result, the heat sink, including the conducting plate **825**, the lens ring **402**, and the thermal conductor **106**, forms a thermal conduction path from the chip **815** to the external environment. By increasing the effective heat transfer surface area of the chip **815**, the heat sink as described dissipates heat produced by the chip **815** to the external environment, thereby cooling the chip **815** and preventing damage to the electronics.

Additional Configuration Considerations

Throughout this specification, some embodiments have used the expression “coupled” along with its derivatives. The term “coupled” as used herein is not necessarily limited to two or more elements being in direct physical or electrical contact. Rather, the term “coupled” may also encompass two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other, or are structured to provide a thermal conduction path between the elements.

Likewise, as used herein, the terms “comprises”, “comprising”, “includes”, “including”, “has”, “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus.

In addition, use of the “a” or “an” are employed to describe elements and components of the embodiments herein. This is done merely for convenience and to give a general sense of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

Finally, as used herein any reference to “one embodiment” or “an embodiment” means that a particular element, feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase “in one embodiment” in various places in the specification are not necessarily all referring to the same embodiment.

Upon reading this disclosure, those of skill in the art will appreciate still additional alternative structural and functional designs for a camera expansion module as disclosed from the principles herein. Thus, while particular embodiments and applications have been illustrated and described, it is to be understood that the disclosed embodiments are not limited to the precise construction and components disclosed herein. Various modifications, changes and variations, which will be apparent to those skilled in the art, may be made in the arrangement, operation and details of the method and apparatus disclosed herein without departing from the spirit and scope defined in the appended claims.

The invention claimed is:

1. A camera, comprising:

a camera body having a camera lens structured on a front surface of the camera body;

electronics internal to the camera body, the electronics for capturing images via the camera lens; and

an internal heat sink thermally coupled to the electronics for dissipating heat produced by the electronics; and

a thermally conductive lens ring positioned around the camera lens of the camera on the front surface of the camera body and partially covered by a thermally insulating material, the lens ring thermally coupled to the heat sink internal to the camera body to transfer the heat produced by the electronics from the internal heat sink to an exterior of the camera body.

2. The camera of claim **1**, wherein the lens ring forms at least a partial ring around the camera lens.

3. The camera of claim **1**, further comprising a lens cover removably coupled to the camera body and making contact with the lens ring when coupled to the camera body, wherein the heat produced by the electronics is transferred from the lens ring to the lens cover.

4. The camera of claim **3**, wherein the lens cover comprises a plurality of fins structured to provide a surface area for conducting the heat to the exterior of the camera body.

5. The camera of claim **1**, wherein the camera body comprises a first material, and wherein the lens ring comprises a second material having a higher thermal conductivity than the first material.

6. A camera, comprising:

a camera body having a camera lens structured on a front surface of the camera body;

electronics internal to the camera body, the electronics for capturing images via the camera lens;

an internal heat sink thermally coupled to the electronics for dissipating heat produced by the electronics; and

a thermally conductive lens ring positioned around the camera lens of the camera on the front surface of the camera and substantially flush with the front surface of the camera body, the lens ring thermally coupled to the heat sink internal to the camera body to transfer the heat produced by the electronics from the internal heat sink to an exterior of the camera body.

7. The camera of claim **6**, wherein the lens ring forms at least a partial ring around the lens.

8. The camera of claim **6**, further comprising a lens cover removably coupled to the camera body and making contact with the lens ring when coupled to the camera body, wherein the heat produced by the electronics is transferred from the lens ring to the lens cover.

9. The camera of claim **8**, wherein the lens cover comprises a plurality of fins structured to provide a surface area for conducting the heat to the exterior of the camera body.

10. The camera of claim **6**, wherein the camera body comprises a first material, and wherein the lens ring comprises a second material having a higher thermal conductivity than the first material.

11. A camera, comprising:

a camera body comprising a first material, the camera body having a camera lens structured on a front surface of the camera body;

electronics internal to the camera body, the electronics for capturing images via the camera lens; and

a heat sink comprising a second material having a higher thermal conductivity than the first material, the heat sink thermally coupled to the electronics and comprising a thermally conductive surface positioned on the front surface of the camera body, the heat sink dissipating heat produced by the electronics to an exterior of the camera body.

12. The camera of claim **11**, wherein the thermally conductive surface comprises a lens ring forming at least a partial ring around the camera lens.

13. The camera of claim **11**, further comprising a thermally insulating material covering at least a portion of the thermally conductive surface.

14. The camera of claim **11**, wherein the thermally conductive surface is substantially flush with the front surface of the camera body.

15. The camera of claim **11**, wherein the thermally conductive surface is recessed beneath the front surface of the camera body.

16. The camera of claim **11**, wherein the lens ring comprises a plurality of fins structured to provide a surface area for conducting the heat to the exterior of the camera body.

17. A camera, comprising:

a camera body having a camera lens structured on a front surface of the camera body;

electronics internal to the camera body, the electronics for capturing images via the camera lens;

a heat sink thermally coupled to the electronics and comprising a thermally conductive surface positioned on the front surface of the camera body, the heat sink dissipating heat produced by the electronics to an exterior of the camera body; and

a lens ring removably coupled to the camera body and making contact with the thermally conductive surface when coupled to the camera body, wherein the heat produced by the electronics is transferred from the thermally conductive surface to the lens ring.

18. The camera of claim **17**, wherein the front surface of the camera body comprises a reciprocal cavity structured to receive the lens ring, and wherein the lens ring comprises a planar component substantially flush with the front surface of the camera body when the lens ring is coupled to the camera body within the reciprocal cavity.

19. The camera of claim **17**, further comprising a lens cover removably coupled to the camera body and making contact with the lens ring when coupled to the camera body, wherein the heat produced by the electronics is transferred from the lens ring to the lens cover.

20. The camera of claim **19**, wherein the lens ring comprises a plurality of fins structured to provide a surface area for conducting the heat to the exterior of the camera body.

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